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8- BY 14-FOOT GUST TUNNEL

The gust tunnel is unconventional in character. The apparatus consists of a catapult for launching dynamically scaled models in steady flight, a tunnel to provide a jet of air of known characteristics to simulate a gust, curtains for stopping and catching the model after traversing the gust, and suitable instruments for recording the reactions of the models in the simulated gust. Supplementary equipment includes a traveling dynamic balance for determining the lift, drag, and moment of restrained models and the aerodynamic forces acting on the component parts of an airplane in unsteady flow. The gust tunnel provides means of determining the reactions of dynamically scaled models in known gusts under closely controlled conditions and may be used as follows: To calibrate airplanes which have been used as instruments in investigations of atmospheric turbulence or upon which a significant amount of gust load data has been obtained; to test special models for studying unsteady flow phenomena; to predict the gust load factor for new designs; and to test gust alleviation devices. The traveling dynamic balance will be used to verify theoretical work and to determine the behavior in unsteady flow for cases which theoretical analysis is either impractical or of doubtful value.

The pertinent characteristics of the gust tunnel are as follows:

(1) Characteristics of catapult

Type	Compressed air
Speed range, mph	30 to 100
Accelerating distance	50 feet
Model size handled	7-foot span maximum
Model weight, maximum	40 pounds

(2) Characteristics of tunnel

Tunnel	8- by 14-foot gust
Location	LMAL
Type	Reversible single return
Jet type	Open throat, adjustable angle
Jet shape	Rectangular, 8 by 14-feet
Contraction ratio	Negative 2.96
Horsepower	75
Velocity range, mph	0 to 14
Operating pressure	Atmospheric
Energy ratio	0.02 (approx.)
Screen losses	10 q (approx.)
Reference	None

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(3) Primary recorded data (free model tests)

Time histories	Acceleration, pitch angle and vertical displacement
Velocities	Forward speed and gust velocity

(4) Traveling dynamic balance

Maximum forward speed	60 mph
Model size	3-foot span
Natural frequency of balance	130 cycles per second
Measurements	Lift, drag, and moment

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24-INCH HIGH-SPEED TUNNEL

Tunnel	24-inch high-speed
Location	LMAL
Type	Induction, nonreturn
Type model	Two-dimensional and three-dimensional
Jet type	Closed throat
Jet shape	Circular cross section with large chord flats
Jet dimensions	24-inch diameter (18 inches between flats)
Jet length	Approximately 16 inches
Contraction ratio	This term is not applicable as for conventional wind tunnels. Air flow is induced from the atmosphere.
Operating pressure range	Atmospheric
Horsepower	Driven by an induction jet; maximum operating conditions are an induction jet chamber pressure of 180 psi and a discharge rate of 55 lb/sec.
Dynamic pressure range, lb/ft ²	55 to 785
Speed range, mph	155 to 695
Mach number range	0.2 to 1.0 tunnel empty (speed limited by choking conditions for model tests)
Turbulence factor	1.1 (approx.)
Energy ratio	2.05 (maximum) Decreases with decrease in Mach number. Not strictly comparable with conventional wind tunnels.
Reference	TR 646 and ACR L4LO7a
Remarks	

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8-FOOT HIGH-SPEED TUNNEL

Tunnel	8-foot high speed
Location	LMAL
Type	Single return
Type model	Tip-supported or three-dimensional
Jet type	Closed throat
Jet shape	Round (with vertical flats)
Jet dimensions	8-foot diameter (7 feet 7 inches between flats)
Jet length	1.8 diameter
Contraction ratio	9.0
Operating pressure range	Atmospheric
Horsepower	16,000
Dynamic pressure range, lb/ft ²	0 to 800
Velocity range, mph	0 to 750
Mach number range	0 to 1.00 tunnel empty (speed limited by choking conditions for model tests)
Turbulence factor	1.01 to 1.06 (based on hot-wire measurements of longitudinal and lateral turbulence)
Energy ratio	7.5
Reference	None
Remarks	

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16-FOOT HIGH-SPEED TUNNEL

Tunnel	16-foot high speed
Location	LMAL
Type	Single return
Type model	Tip-supported or three-dimensional
Jet type	Closed throat
Jet shape	Circular (with vertical flats)
Jet dimensions	16-foot diameter (15 feet between flats)
Jet length	24 feet (1.5 diameter)
Contraction ratio	13.4
Operating pressure range	Atmospheric
Horsepower	16,000
Dynamic pressure range, lb/ft ²	0 to 540
Velocity range, mph	0 to 525
Mach number range	0 to 0.70
Turbulence factor	Low but not quantitatively determined
Energy ratio	9.5
Reference	None
Remarks	

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MODEL SUPERSONIC TUNNEL

Tunnel	Model supersonic
Location	LMAL
Type	Direct action, nonreturn
Type model	Three-dimensional or two-dimensional
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	7-1/2 inches wide by 7-1/2 to 9 inches high
Jet length	1-1/2 times width (approx.)
Contraction ratio	100 to 1 for smallest nozzle minimum and 70 to 1 for largest nozzle minimum
Operating pressure range	Stream pressures from 1/5 to 1/3 atmospheric pressure
Horsepower	1000
Dynamic pressure range, lb/ft ²	1200 to 1400
Velocity range, mph	1000 to 1200
Mach number range	1.35 to 2.0
Turbulence factor	Not determined
Energy ratio	1.6
Reference	None
Remarks	

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RECTANGULAR HIGH-SPEED TUNNEL

Tunnel	Rectangular high speed
Location	LMAL
Type	Induction, nonreturn
Type model	Two-dimensional
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	4- by 18-inch (4-inch dimension fixed, 18-inch dimension variable)
Jet length	10 inches (approx.)
Contraction ratio	This term is not applicable as for conventional wind tunnels. Air flow is induced from the atmosphere.
Operating pressure range	Atmospheric
Horsepower	Induction type tunnel utilizing a maximum of 15 pounds of air per second at pressures up to 290 psi in an annular nozzle downstream of test section.
Dynamic pressure range, lb/ft ²	55 to 910
Velocity range, mph	155 to 915
Mach number range	Approximately 0.2 to 1.4 (choking prevents testing at Mach numbers in the neighborhood of 1)
Turbulence factor	Has not been determined
Energy ratio	Approximately 1.5. This term varies over the Mach number range and is not strictly comparable with conventional wind tunnels.
Reference	Stack, John: Compressibility Effects in Aeronautical Engineering. NACA ACR, 1941
Remarks	

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FULL-SCALE TUNNEL

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1/15-SCALE MODEL OF FULL-SCALE TUNNEL

Tunnel	Full-scale	1/15-scale model of full-scale
Location	LMAL	LMAL
Type	Double return	Double return
Type model	Three-dimensional	Three-dimensional
Jet type	Open throat	Open throat
Jet shape	Elliptical	Elliptical
Jet dimensions	60 by 30 feet	4 by 2 feet
Jet length	56 feet	3.73 feet
Contraction ratio	4.93	4.93
Operating pressure range	Atmospheric	Atmospheric
Horsepower	8000	30
Dynamic pressure range, lb/ft ²	1.5 to 36	0 to 19
Velocity range, mph	25 to 118	5 to 85
Mach number range	0.03 to 0.16	0 to 0.11
Turbulence factor	1.1	1.2
Energy ratio	2.84	1.50
Reference	TR 459	TR 478
Remarks		Not equipped with balance

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INDUCTION AERODYNAMICS LABORATORY

Location

Floor area for test setups

Test cell

Air supply

LMAL

100 feet by 120 feet

22 feet by 22 feet by 118 feet

3- to 1000-horsepower blowers

		Volume blower	Pressure blower	Compressor	Volume blower & pressure blower in parallel	Volume blower & pressure blower in series	Pressure blower & compressor in series
Rated	*Capacity, C. F. M.	85,000	44,000	13,800	----	----	----
	Pressure above atmospheric, lb/ft ²	265	530	2,116	----	----	----
	Pressure below atmospheric, lb/ft ²	240	425	1,058	----	----	----
Maximum flow	Capacity, C. F. M.	128,000	65,000	----	182,000	----	----
	Pressure above atmospheric, lb/ft ²	89	145	----	145	----	----
	Pressure below atmospheric, lb/ft ²	87	141	----	150	----	----
Maximum pressure	Capacity, C. F. M.	45,000	25,000	9,000	----	35,000	13,800
	Pressure above atmospheric, lb/ft ²	325	655	2,350	----	970	2,900
	Pressure below atmospheric, lb/ft ²	285	500	1,110	----	660	1,220
*Flow quantities given are corrected back to the temperature and pressure at the entrance to the blower.							

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TWO-DIMENSIONAL LOW-TURBULENCE TUNNEL

Tunnel	Two-dimensional low-turbulence
Location	LMAL
Type	Single return
Type model	Two-dimensional (limited three-dimensional models such as nacelles on wing sections)
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	3- by 7-1/2 foot
Jet length	7-1/2 feet
Contraction ratio	18:1
Operating pressure range	Atmospheric
Horsepower	195
Dynamic pressure range, lb/ft ²	0 to 65
Velocity range, mph	0 to 159
Mach number range	0 to 0.215
Turbulence factor	1.0
Energy ratio	3.0
Maximum Reynolds number	1.48×10^6 per foot of chord
Reference	None
Remarks	<p>(a) Standard airfoil characteristics tests are made with 24-inch chord models. Maximum lift characteristics cannot be obtained with models having a chord larger than 36 inches. Drag characteristics at low lift coefficients can be obtained with models having chords up to 100 inches.</p> <p>(b) Turbulence of the air stream of this wind tunnel is very low. Fluctuating components of velocity are a few hundredths of 1 percent.</p>

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TWO-DIMENSIONAL LOW-TURBULENCE PRESSURE TUNNEL

Tunnel	Two-dimensional low-turbulence pressure
Location	LMAL
Type	Single return
Type model	Two-dimensional (limited three-dimensional models such as nacelles on wing sections)
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	3- by 7-1/2 foot
Jet length	7-1/2 feet
Contraction ratio	17-1/2:1
Operating pressure range	1 to 10 atmospheres
Horsepower	2000
Dynamic pressure range, lb/ft ²	0 to 670
Velocity range, mph	0 to 300 (one atmosphere) 0 to 220 (four atmospheres) 0 to 160 (ten atmospheres)
Mach number range	0 to 0.4 (one atmosphere) 0 to 0.3 (four atmospheres) 0 to 0.2 (ten atmospheres)
Turbulence factor	1.0
Energy ratio	3.5
Maximum Reynolds number	14×10^6 per foot of chord
Reference	None
Remarks	(a) Standard airfoil characteristics tests are made with 24-inch chord models. Maximum lift characteristics cannot be obtained with models having a chord larger than 36 inches. Drag characteristics at low-lift coefficients can be obtained with models having chords up to 100 inches. (b) Turbulence of the air stream of this wind tunnel is very low. Fluctuating components of velocity are a few hundredths of 1 percent.

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19-FOOT PRESSURE TUNNEL

Tunnel	19-foot pressure
Location	LMAL
Type	Single return
Type model	Three-dimensional
Jet type	Closed throat
Jet shape	Round
Jet dimensions	19-foot diameter
Jet length	1-1/2 diameters
Contraction ratio	8:1
Operating pressure	
range	1 to 2-1/3 atmospheres
Horsepower	8000
Dynamic pressure	
range, lb/ft ²	12 to 175 (1 atmosphere)
	15 to 250 (2-1/3 atmospheres)
Velocity range, mph	70 to 260 (1 atmosphere)
	50 to 210 (2-1/3 atmospheres)
Mach number range	0.09 to 0.34 (1 atmosphere)
	0.07 to 0.28 (2-1/3 atmospheres)
Turbulence factor	
Before installation	
of screen	1.03 from tests of 8-inch sphere (1 atmosphere)
	$\frac{\sqrt{u^2}}{U} \quad 0.003, \frac{\sqrt{v^2}}{U} \quad 0.006$ from hot-wire measurements (1 atmosphere)
	No data available for 2-1/3 atmospheres
After installation	
of screen	No data available for 1 atmosphere
	No data available from tests of 8-inch spheres (2-1/3 atmospheres)
	$\frac{\sqrt{u^2}}{U} \quad 0.002, \frac{\sqrt{v^2}}{U} \quad 0.005$ from hot-wire measurements (2-1/3 atmospheres)
Energy ratio	7.5
Reference	None published
Remarks	

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20-FOOT PROPELLER RESEARCH TUNNEL

Tunnel	20-foot propeller research
Location	LMAL
Type	Double return
Type model	Three-dimensional
Jet type	Open throat
Jet shape	Round
Jet dimensions	20-foot diameter
Jet length	1.75 diameters
Contraction ratio	7.97
Operating pressure range	Atmospheric
Horsepower	1800
Dynamic pressure range, lb/ft ²	0 to 31
Velocity range, mph	0 to 110
Mach number range	0 to 0.14
Turbulence factor	1.2
Energy ratio	1.39
Reference	TR 300
Remarks	

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FLUTTER TUNNEL

Tunnel	Flutter	
Location	LMAL	
Type	Single return	
Type model	Three-dimensional	
Jet type	Closed throat	
Jet shape	Circular	
Jet dimensions	4-1/2 foot diameter	
Jet length	9 feet	
Contraction ratio	8.93	
Operating pressure range	0 to 1.8 atmospheres (approx.)	
Horsepower	1000	
Dynamic pressure range, lb/ft ²	0 to 812	} Calculated assuming energy ratio equal to 8-1/4 to 1 atmosphere pressure at throat
Velocity range, mph	0 to 975	
Mach number range	0 to 1.00	
Energy ratio	8	
Turbulence factor	Not known	
Reference		
Remarks	<ol style="list-style-type: none"> 1. Two mobile interchangeable test sections: <ol style="list-style-type: none"> (a) Four-component hydraulic balance test section (b) Flutter test section, 17 viewing portholes 2. Charge cooled by two alternate methods: <ol style="list-style-type: none"> (a) Exchanging portion of charge for atmospheric air (b) Passing portion charge through heat exchanger 3. Entire tunnel designed to hold 0 to 1.8 atmospheres of Freon 12 as testing medium. 	

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ATMOSPHERIC WIND TUNNEL

Tunnel	Atmospheric wind
Location	LMAL
Type	Single return - horizontal
Type model	Three-dimensional, two-dimensional, and partial-span (reflection plane)
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	7 by 10 feet
Jet length	11 feet
Contraction ratio	4.0
Operating pressure range	Atmospheric
Horsepower	200
Dynamic pressure range, lb/ft ²	0 to 16.37
Velocity range, mph	0 to 80
Mach number range	0 to 0.11
Turbulence factor	1.6
Energy ratio	1.4
Reference	TR 412 and TR 664
Remarks	Tunnel equipped with six-component balance and scale system

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300-MILE-PER-HOUR 7- BY 10-FOOT WIND TUNNEL

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HIGH-SPEED 7- BY 10-FOOT WIND TUNNEL

Tunnel	300-mile-per-hour 7- by 10-foot	High-speed 7- by 10-foot (under construction)
Location	LMAL	LMAL
Type	Single return	Single return
Type models	Three-dimensional, two-dimensional, and semispan	Three-dimensional, two-dimensional, and semispan
Jet type	Closed throat	Closed throat
Jet shape	Rectangular	Rectangular
Jet dimensions	7 by 10 feet	7 by 10 feet
Jet length	15 feet	15 feet
Contraction ratio	14	14
Operating pressure range	Atmospheric	Atmospheric
Horsepower	1600	10,000
Dynamic pressure range, lb/ft ²	0 to 200	
Velocity range, mph	0 to 300	
Mach number range	0 to 0.40	
Turbulence factor		
Energy ratio	7	
Reference		
Remarks	A feature of both tunnels is contained in a remotely controlled survey apparatus which is constructed as an inherent part of the tunnels and which permits the rapid exploration of air flow behind models. Both tunnels equipped with six-component balance systems. The high-speed tunnel is to be provided with an adjustable test section.	

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FREE-FLIGHT TUNNEL

Tunnel	12-foot free flight
Location	LMAL
Type	Open return
Type model	Three-dimensional dynamic
Jet type	Closed throat
Jet shape	12-sided polygon
Jet dimensions	12-foot (across flats)
Jet length	1.25 diameters
Contraction ratio	4
Operating pressure range	Atmospheric
Horsepower	
Rated	280
5-minute rating	570
Dynamic pressure range, lb/ft ²	0 to 9
Velocity range, mph	0 to 60
Mach number range	0 to 0.08
Turbulence factor	1.6
Energy ratio	0.5
Reference	TN 810
Remarks	Free-flying remotely controlled dynamic models are tested in the tunnel. The longitudinal axis of the test section of the tunnel can be tilted through a range of angles corresponding to 15° climb and 45° glide. The tunnel is housed in a 60-foot steel sphere which provides uniform return passage at all angles of tilt.

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4- BY 6-FOOT TUNNEL

Tunnel	4- by 6-foot
Location	LMAL
Type	Single return - vertical
Type of model	Three-dimensional, two-dimensional, and partial-span (reflection plane)
Jet type	Closed throat
Jet shape	Rectangular
Jet dimensions	4 by 6 feet
Jet length	4.5 feet
Contraction ratio	3.37
Operating pressure range	Atmospheric
Horsepower	50
Dynamic pressure range, lb/ft ²	0 to 15
Velocity range, mph	0 to 76
Mach number range	0 to 0.11
Turbulence factor	1.93
Energy ratio	1.4
Reference	TR 387 and TN 734
Remarks	Tunnel equipped with three-component balance and scale system

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20-FOOT FREE-SPINNING WIND TUNNEL

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15-FOOT FREE-SPINNING WIND TUNNEL

Tunnel	20-foot free spinning	15-foot free spinning
Location	LMAL	LMAL
Type	Vertical with annular return	Vertical without direct return
Type model	Dynamic	Three-dimensional
Jet type	Closed throat	Closed throat
Jet shape	12-sided polygon	12-sided polygon
Jet dimensions	20 feet across flats	15-feet across flats
Jet length	1.5 diameter	1.26 diameter
Contraction ratio	4.0	2.9
Operating pressure range	Atmospheric	Atmospheric
Horsepower		
Rated	400	150
5-minute rating	1300	260
Dynamic pressure range, lb/ft ²	0 to 10	0 to 4
Velocity range, mph	0 to 62	0 to 40
Mach number range	0 to 0.08	0 to 0.05
Turbulence factor		
Energy ratio	0.52	0.35
Reference		TR 557
Remarks		

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STABILITY TUNNEL

Tunnel	Stability		
Location	LMAL		
Type	Single return		
Type models	Three-dimensional, two-dimensional, and semispan		
Jet type	Closed throat (interchangeable jets)		
Jet shapes	Square	Round	Rectangular
Jet dimensions	6 by 6 feet	6.3-foot diameter	6 by 2-1/2 feet
Jet length	22 feet	22 feet	6 feet
Contraction ratio	9	10.5	21.6
Operating pressure range	Atmospheric	Atmospheric	Atmospheric
Horsepower	600	600	600
Dynamic pressure range, lb/ft ²	0 to 125	0 to 125	0 to 350
Velocity range, mph	0 to 220	0 to 220	0 to 360
Mach number range	0 to 0.29	0 to 0.29	0 to 0.47
Turbulence factor	1.04	1.04	1.0
Energy ratio	5.0	5.0	17
Reference			
Remarks	An unusual feature of the 6- by 6-foot square test section of the stability tunnel is the fact that the sides of the test section are adjustable. The sides can be adjusted to different radii of curvature so that models can be tested in curved flow simulating flight in curved paths of different radii.		

The 6.3-foot diameter round test section is provided with rotating vanes. The rate of rotation can be adjusted as to give a predetermined twist to the air stream. In this way, different rates of roll can be simulated while the model is stationary and the different aerodynamic forces can easily be measured by the balance system.

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INSTRUMENT RESEARCH WIND TUNNEL

Tunnel	Instrument research
Location	LMAL
Type	Open return
Type model	Three-dimensional
Jet type	Closed throat
Jet shape	Round
Jet dimensions	15-inch diameter
Jet length	28 inches
Contraction ratio	20:1
Operating pressure range	14.7 to 11 lb/in ² (approx.)
Horsepower	300
Dynamic pressure range, lb/ft ²	3.6 to 520 (estimated)
Velocity range, mph	40 to 500 (estimated)
Mach number range	0.052 to 0.65 (estimated)
Turbulence factor	Not known
Energy ratio	3 (estimated)
Reference	None
Remarks	Especially built for testing small components of instru- ments to obtain the charac- teristics, from an instru- mental point of view, as affected by the air stream velocity and direction.

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LOW-VELOCITY INSTRUMENT TUNNEL

Tunnel	Low-velocity instrument (old gust tunnel)
Location	LMAL
Type	Open return
Type model	Three-dimensional (instrument)
Jet type	Closed throat
Jet shape	Square
Jet dimensions	36 inches by 36 inches
Jet length	36 inches
Contraction ratio	2.6:1
Operating pressure range	Atmospheric
Horsepower	
Dynamic pressure range, lb/ft ²	
Velocity range, mph	0 to 35 (estimated)
Mach number range	
Turbulence factor	Not known
Energy ratio	Not known
Reference	None
Remarks	This tunnel was built by remodeling the old gust tunnel. It is shared with the Fluids and Gas Dynamic Analysis Section. The test section and diffuser section are removable and interchangeable with a cascade section belonging to FGDA. It is used by Instrument Research Division for tests of low-velocity instruments, including hot-wire anemometers and other wind direction and velocity instruments.

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